Fort Peck Pallid Sturgeon Study

by

Pat Clancey
Fisheries Biologist
Montana Department of Fish, Wildlife, and Parks

submitted to
U.S. Army Corps of Engineers
Planning Branch
Omaha, Nebraska
March 1991

report period
January 1, 1990 - December 31, 1990

ABSTRACT

The U.S. Fish and Wildlife Service listed the pallid sturgeon as an Endangered Species on October 9, 1990. As a result, a Pallid Sturgeon Recovery Team was formed. The eight member team is composed of state, federal, and university biologists from Montana, North Dakota, South Dakota, Nebraska, Missouri, Louisiana, and Florida. The group had an introductory meeting in December in Springfield, Missouri, and plans to hold three or four meetings in 1991.

Two pallid sturgeon were captured in the Fort Peck tailrace in the winter of 1990, and, working with USFWS personnel, four more were captured in the Missouri River below the mouth of the Yellowstone River in September 1990.

The two pallids captured in the Fort Peck tailrace were mounted with combination radio telemetry/sonic transmitters. Initially, both were easily relocated with the sonic component while still in the tailpool. In April, the sonic receiver began giving erratic signals, and was returned to the manufacturer for repair. During this time the telemetry system was used to monitor for emigration of the pallids from the tailpool, but none was detected. However, when the sonic receiver was returned, we found no trace of the pallids. Neither of these pallids was relocated during the remainder of the year.

The four pallid sturgeon captured in September were mounted with simple radio telemetry transmitters. One of these fish has been relocated twice, and one of them has been relocated once, since that time. Much of the river is over 15 feet deep in this vicinity, so if the fish are in one of these areas, we cannot detect the signal. Each time we have relocated one of these fish, it has been within a mile of the original capture site.

Shovelnose sturgeon were captured from the Tongue River in southeast Montana for use as a surrogate species in the development of an artificial propagation program for the pallid.

Respondents to a pallid sturgeon questionnaire have provided valuable information concerning locations to fish for pallids and described a couple of pallids larger than any we've captured since studies began.

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INTRODUCTION

This report summarizes the second year of work of the Fort Peck Pallid Sturgeon Study. The study began on April 1, 1989, with a contract between the U.S. Army Corps of Engineers (Corps) and the Montana Department of Fish, Wildlife, and Parks (MDFWP). In the first year of study, three pallid sturgeon were captured in the Fort Peck tailrace in March, 1989, and mounted with radio telemetry transmitters (Clancey 1990). Two of these pallids migrated downstream in the spring and were easily tracked. The third pallid was never relocated with telemetry, but was recaptured in a gillnet in August, 1989, in the Fort Peck tailrace. It apparently stayed in the 40-foot deep waters of the tailrace all summer. The radio telemetry signal attenuates rapidly due to the conductivity of the river water, and is not detectible beyond approximately 15-feet deep. All three fish sloughed their transmitters- the two that moved downstream about three months after they were tagged, the third had dropped its by the time it was recaptured in August.

The pallid sturgeon was listed as an Endangered Species by the U.S. Fish and Wildlife Service on October 9, 1990 (Federal Register 1990). A Pallid Sturgeon Recovery Team was formed to develop a biological plan for the recovery of the species. The eight member team is composed of state biologists from the states of Montana, South Dakota, Missouri, and Louisiana, two USFWS biologists from the Bismarck office, a Corps of Engineers biologist from Omaha, and a sturgeon reproductive biologist from the University of Florida. Montana has formed a pallid sturgeon committee to develop Montana's input to the recovery team, to guide recovery of the species in Montana, to elevate the visibility of the pallid in the state, and to review and comment on any fisheries or water development projects which could potentially affect the pallid in Montana.

Input was provided to the development of a sturgeon study plan for the Yellowstone River from Forsyth to Intake, including the Tongue and Powder Rivers. The proposal will be submitted to the Bureau of Reclamation (BOR) for funding. The proposed rebuilding of the Tongue River Dam provided the opportunity for one field season to research the presence and status of pallid sturgeon in that stretch of the Yellowstone River and its associated tributaries.

STUDY AREA

The study area is the Missouri River downstream of Fort Peck Dam to Lake Sakakawea in North Dakota, and the Yellowstone River from its mouth to Intake diversion dam near Glendive, Montana (Figure 1).

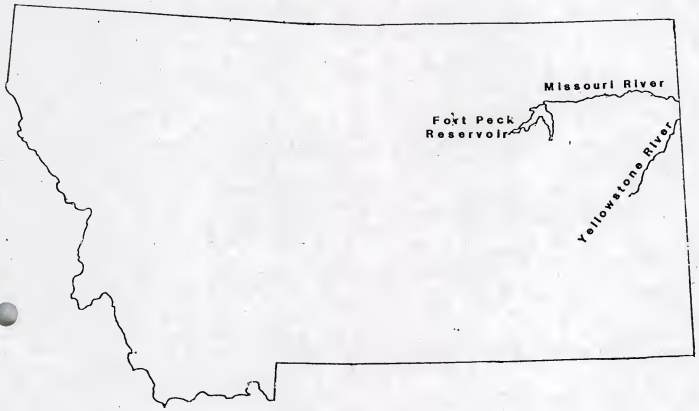


Figure 1. Map of Montana showing Missouri River below Fort Peck Reservoir and Yellowstone River below Glendive.

Discharge of the Missouri River is regulated below Fort Peck Dam, and though it is significantly altered morphologically from its natural condition, is relatively unaltered when compared to the impounded and channelized Missouri River downstream of Montana. The hydrograph (Figure 2) and some water quality characteristics, specifically turbidity and temperature, are significantly altered from natural conditions. Accelerated streambank erosion and channel downcutting occur due to the fluctuating water levels in the river and to the "clean" water releases from Fort Peck Dam.

The Yellowstone River is unimpeded for its entire course, except for run-of-the-river irrigation dams. It exhibits a natural hydrograph and water quality characteristics.

METHODS

Field methods were mostly unchanged from the previous year (Clancey 1990). Two transmitters deployed during SCUBA surveys in February and March, 1990, contained a sonic component as well as a radio telemetry component. This was to allow relocation of the pallid sturgeon in water deeper than 15 feet.

Morphological measurements taken from pallid and shovelnose sturgeon are shown in Figure 3. Fin ray counts were not performed on pallid sturgeon because the thickness of the fins makes accurate counts very difficult.

Larval fish nets with a mouth opening of one meter and a mosquito net lining were used to sample for larval sturgeon. Sampling occurred in the Yellowstone River along shoreline gravel areas and in mid-river, open water areas. The nets were towed both with and against the current.

We cooperated with the USFWS in capturing shovelnose sturgeon from the Tongue River in the spring of 1990. These shovelnose were used as surrogates in attempts to develop an artificial propagation program for pallid sturgeon. The shovelnose were captured either by drifting gillnets or by electrofishing. Captured fish were then transported to the State of Montana Miles City Hatchery and held in indoor raceways. Shovelnose were incised lateral of the ventral midline, sexed, and several eggs were removed from females and the stage of egg development was determined (University of California 1988). Females were injected with hormone to facilitate ovulation, and eggs were surgically removed and fertilized with sperm that was removed from the males. The fertilized eggs were transported to the Gavins Point National Fish Hatchery in Yankton, South Dakota, for rearing and feeding experiments.

A brochure/questionnaire was developed to publicize the pallid sturgeon issue and to gather information from anglers throughout the Missouri-Yellowstone Basin about the history of the pallid. It

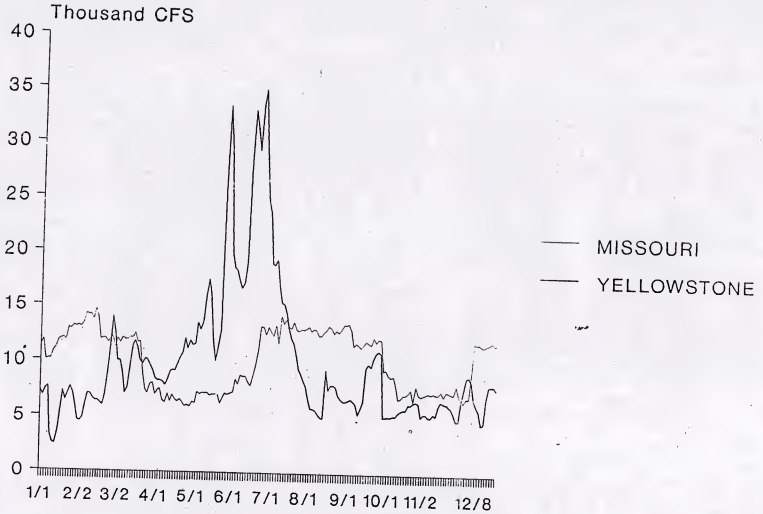


Figure 2. Hydrographs of the Missouri River below Fort Peck Dam and the unaltered Yellowstone River.

A: head length

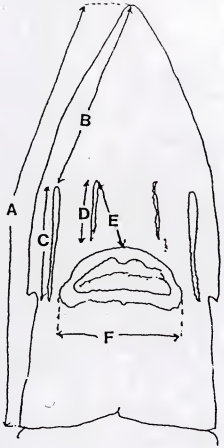
B: tip of snout to base of outer barbel

C: outer barbel length

D: inner barbel length

E: anterior midpoint of mouth to base of inner barbels

F: mouth width



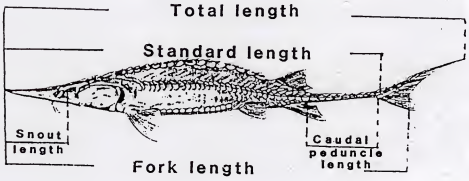


Figure 3. Morphological measurements taken from pallid and shovelnose sturgeon in the Missouri and Yellowstone Rivers.

was distributed to all hunting/fishing license agents along the two rivers, to stores which carry sporting goods, to senior citizens' centers, and copies were sent to all sportsmans clubs in the eastern half of Montana and to known individual sturgeon anglers. The questionnaire was publicized through a newspaper article in the Billings Gazette, one of the most widely circulated newspapers in eastern and central Montana.

RESULTS AND DISCUSSION

Two pallid sturgeon were captured in the Fort Peck tailpool during SCUBA surveys in the winter of 1990, and, in conjunction with USFWS crews, four were captured in drifting gillnets in the Missouri River below its confluence with the Yellowstone in September 1990 (Table 1). One of the fish captured in the tailpool was a recapture from 1989. This fish was outfitted with a transmitter in 1989 and was tracked about 50 river miles downstream from the tailpool area before it dropped its transmitter. This fish probably summered in the Missouri River in Montana.

Both of the pallids captured in the tailpool in 1990 were mounted with combination telemetry/sonic transmitters. The telemetry component is used to track and relocate the fish from an aircraft, however, this system is effective only when the signal source is less than about 15 feet deep. When the signal source is greater than 15 feet, the sonic component must be used. This requires the submersion of a hydrophone in the water, so cannot be used from an aircraft. Either system by itself is of limited effectiveness in the Missouri/Yellowstone System because of the large area the fish potentially may inhabit. Most of the river system is less than 15 feet deep, so the telemetry component is adequate to track the fish in those areas. However, in general the pallid seems to select the deepest area available. This means that the fish may spend most of their time in the relatively small portion of the river that is greater than 15 feet deep where it is necessary to use the sonic component to locate them.

Initially, both fish were easily located with the sonic system while still in the tailpool, however, problems with the sonic receiver required the return of the receiver to the manufacturer two times for repair. The radio telemetry system was used to monitor emigration of the pallids from the tailrace, but none was detected. Subsequent surveys with the repaired sonic receiver located neither of the pallids, and neither of these fish was relocated again during the year.

All four pallids captured near the confluence were netted in water 20-30 feet deep and were outfitted with simple radio telemetry transmitters. Two of these fish have been relocated since their capture, always within a mile or so of their original capture site. On some flights, none of these fish are relocated. The inconsistency of relocating these fish is probably due to their movements in and out of water greater than 15 feet deep. Habitat data was collected from only one relocation prior to the river freezing over in December.

Table 1. Morphological measurements taken from five pallid sturgeon captured in the Missouri River downstream of Fort Peck in 1990. Measurements are in millimeters, percent of standard length is in parentheses. Only "new" fish are reported.

	transmitter number				
	227	477	127	101	076
capture date	2/10	9/13	9/13	9/14	9/17
weight (lbs)	44	33	35	39	40
total length	1600	1455	1499	1554	1554
fork length	1494	1380	1397	1455	1448
standard length	1417	1308	1346	1356	1372
	(100)	(100)	(100)	(100)	(100)
head length	503	452	427	457	460
	(35.5)	(34.5)	(31.6)	(33.7)	(33.5)
mouth width	132	104	109	124	--
	(9.3)	(8.0)	(8.1)	(9.2)	
snout to outer barbel	229	--	--	208	198
	(16.1)			(15.4)	(14.4)
mouth to inner barbel	61	--	--	56	58
	(4.3)			(4.1)	(4.3)
inner barbels[1]	64	48	51	43	48
	(4.4)	(3.7)	(3.7)	(3.2)	(3.5)
outer barbels[2]	163	147	132	122	142
	(11.4)	(11.3)	(9.7)	(9.0)	(10.3)
snout length	274	---	---	254	241
	(19.4)			(18.7)	(17.6)
caudal peduncle length	152	--	--	180	188
	(10.8)			(13.3)	(13.7)
belly scutellation	no	no	no	no	no

[1] average of the 2 inner barbels
[2] average of the 2 outer barbels

As reported for the initial year of this study (Clancey 1990), the morphometric ratios for pallid sturgeon found in this study are greater than those found by Bailey and Cross (1954) (Table 2). Gardner (in preparation) reports that most of the pallids captured above Fort Peck Reservoir also exhibit ratios greater than those of Bailey and Cross (1954) for at least some of the characteristics.

Table 2. Comparison of morphometric characteristics of pallid sturgeon found by Bailey and Cross (1954) and those captured in this study in 1990. See Figure 3 for ratio definitions.

		pallid sturgeon number					
		277	477	127	101	076	B&C
E in	B=	3.75	--	--	3.73	3.39	2.3-3.3
	F=	2.15	--	--	2.23	--	1.6-2.0
	A=	8.25	--	--	8.18	7.87	5.5-7.0
D in	B=	3.66	--	--	4.82	4.11	2.6-3.7
	C=	2.59	3.05	2.97	2.82	2.92	1.6-2.4
	A=	8.05	9.34	8.59	10.59	9.53	6.3-8.0

The significance of the disparities between pallid sturgeon from isolated areas of their range is unclear. It is probably linked to the size disparity between pallids in this study area and pallids found in South Dakota and further downstream. The smallest pallid captured to date in this study is 29 pounds, while pallids captured in the Missouri/Mississippi system below Lake Oahe have been less than 15 pounds. A similar phenomenon holds true for shovelnose sturgeon in Montana versus downstream states.

Comparisons of pallid and shovelnose sturgeon morphometric measurements are shown in Table 3. The number of pallid sturgeon used to compute the figures varies because not all characteristics were measured on all the fish, due either to oversight or because those researchers measuring the fish didn't think them important at the time. Based on first hand observations of sturgeon and differences in morphometric characteristics of the two species (Appendix Tables 1 and 2), we do not believe that pallid-shovelnose hybrids are present in either the Missouri or Yellowstone rivers in Montana.

Larval sturgeon sampling was unsuccessful. Towing the nets with the current frequently resulted in the nets dragging the river bottom and filling with gravel, particularly in the

Table 3. Average percent of standard length of selected morphological characteristics of pallid and shovelnose sturgeon. Measurements from pallid sturgeon captured in 1989 and 1990 were pooled to calculate the figures in this table. Only "new" fish are included in this table. Empirical data for individual fish are listed in Appendix Table 1 for the pallid sturgeon and Appendix Table 2 for the shovelnose.

		shovelnose			
		Missouri		Yellowstone	
	pallids	1990 (n=34)	1989 (n=54)	1990 (n=40)	1989 (n=22)
head length	33.5 (n=8)	28.9	29.1	29.2	29.4
snout length	18.1 (n=6)	15.6	15.2	16.0	15.7
mouth width	8.9 (n=7)	7.6	8.4	7.5	8.1
snout to outer barbels	14.7 (n=6)	9.3	9.7	9.5	10.5
mouth to inner barbels	4.2 (n=6)	6.7	6.8	6.3	6.5
inner barbels	3.3 (n=8)	6.2	5.9	6.4	6.5
outer barbels	9.7 (n=8)	8.4	8.0	8.6	8.9
caudal peduncle	12.4 (n=6)	16.0	16.0	14.8	15.3
girth (at widest)	41.7 (n=6)	30.2	34.6	33.9	36.3

shoreline areas. Methods were refined later in the summer and new nets more applicable for the task were acquired. Additional sampling will be carried out in the upcoming field season.

The development of an artificial propagation program using shovelnose sturgeon as a surrogate for the pallid began in 1989. That year, survival to hatching was only four percent. Larval shovelnose sturgeon were fed a variety of feeds, and were about 279-305 millimeters (11-12") in length at just less than one year old. Eggs taken in 1990 exhibited 85-90 percent hatch, but all of the larval shovelnose were deformed with twisted cartilage in the gill arches and degenerative cartilage in the snout (Rob Holm, USFWS, Gavins Point National Fish Hatchery, pers. comm.) Some of these fish are still being held at the Gavins Point Hatchery, and are feeding and growing normally despite their deformities. It is expected that the developing embryos were somehow shocked while in transit to Gavins Point, resulting in the irregularities.

Initial response to the sturgeon questionnaire was good, but decreased after about three months. Some respondents didn't know the difference between the sturgeon species, and provided information on shovelnose rather than pallids. Valuable information was provided by the respondents regarding locations and time of year that they caught pallids. One party caught and released a 1746 mm (68-3/4") pallid in the Missouri River between Poplar and Brockton on May 19, 1990. The location that this fish was caught is within about one mile of the last relocation site we have for pallid 526, but is not the same fish. Pallid 526 was 1626 mm (64") and weighed 53 pounds in March, 1989 (Clancey 1990). One of the anglers stated that the vent on the pallid they caught was red, and that the belly area was "very droopy", implying that the fish was a female that had recently spawned. They estimated this fish to weigh 80 pounds. The fish was caught on an overnight setline baited with a live minnow. The fishing party checked the line every couple of hours until midnight, then found the fish when they again checked the line at about 8 a.m. These anglers took several measurements from the fish, and provided photos to document the catch. Girth was measured at 737 mm (29"), distance between the eyes was 152 mm (6"), tip of snout to the first dorsal scute was 502 mm (19-3/4"), and the distance across the ventral side of the fish from tip of pectoral fin to tip of pectoral fin was 508 mm (20"). One of these anglers has caught three other pallids in the same area, two in recent years, and may have caught "small" pallids also, though he wasn't sure he could tell the difference between small pallids and shovelnose. These fish were always caught in the springtime.

Another angler caught and released a 1702 mm (67"), 72 pound pallid in the Yellowstone River at Sidney in June, 1986, while snagging for paddlefish. He weighed the fish on a scale set up for paddlefish. Other respondents reported snagging pallids at Intake on the Yellowstone River and upstream of Fort Peck Reservoir on the Missouri River while fishing for paddlefish in the spring. One particular angler reports that he used setlines baited with minnows and worms to catch several pallids each year at Sidney during the

spring and early June rise. An angler from Williston estimated that he caught 50 pallids in the early 1960's in the Missouri River between the mouth of the Yellowstone and Williston, usually in August and September. He used large dead suckers on setlines and rod-and-reel, and fished below sandbars in water 20-30 feet deep. All the anglers who report catching pallids in the spring caught them in shallower water, ranging from 4-12 feet.

MDFWP fisheries personnel captured and measured five pallid sturgeon in the Missouri River upstream of Fort Peck Reservoir in 1990 (Gardner, in prep.). Telemetry transmitters were attached to four of these fish, and relocations are intermittent, depending on the depth of the fish.

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Appendix Table 1. Measurements of morphological characters and tag numbers of pallid sturgeon captured in 1989 and 1990. Lengths are in millimeters and weight is in pounds.

	pallid sturgeon number							
	502	526	552	277	477	127	101	076
capture date	3/10/89	3/10/89	3/21/89	2/10/90	9/13/90	9/13/90	9/14/90	9/17/90
capture location[1]	FP	FP	FP	FP	ND	ND	ND	ND
weight	33	53	29	44	33	35	39	40
length								
total	1575	1626	1435	1600	1455	1499	1554	1554
fork	1483	1537	1321	1494	1379	1397	1455	1448
standard	1397	1524	1257	1417	1308	1346	1356	1372
head length	470	508	406	503	452	427	457	460
snout length	254	267	216	274	---	---	254	241
mouth width	127	147	114	132	104	102	124	---
snout-out.barbs	203	206	178	229	---	---	208	198
mouth-in.barbs	58	64	51	61	---	---	56	58
inner barbs[2]	30	46	38	64	48	51	43	48
outer barbs[2]	109	152	99	163	147	132	122	142
caudal peduncle	165	178	165	152	---	---	180	188
PIT tag number[3] (prefix 7F7F0)	65C30	-----	65841	55428	66A0E	72442	66613	54855
yellow disk[4]	1683	-----[5]	1638	1612	1314	1394	1317	1371

[1] FP= Fort Peck Dam tailpool
ND= Missouri River in North Dakota, between the mouth of the Yellowstone River and highway 85.
[2] average of two
[3] injected at the base of the dorsal fin
[4] attached to the posterior base of the dorsal fin
[5] this fish has a green disk tag, number 514.

Appendix Table 2. Empirical measurements and percent of standard length of morphological characters of shovelnose sturgeon captured in the Missouri and Yellowstone rivers in 1990. Lengths are in inches. Definitions of abbreviations precede the table, and some are illustrated in Figure 3. Values for shovelnose captured in 1989 are reported in Clancey (1990).

TL- total length
FL- fork length
SL- standard length
HL- head length (distance from tip of snout to posterior edge of gill opening)
MW- mouth width
SNTOUT- distance from tip of snout to base of outer barbels.
MTHIN- distance from anterior midpoint of mouth to base of inner barbels.
SNTL- distance from tip of snout to anterior edge of eye.
CDPED- distance from posterior base of anal fin to anterior base of caudal fin.
GIR- girth at the widest point of the body (usually just behind the pectoral fins)
DF- number of dorsal fin rays
AF- number of anal fin rays
INBRBS- average length of the two inner barbels
OUTBRBS- average length of the two outer barbels

Missouri River
empirical measurements

row	TLIN	FL	SL	HL	SNTLE	MW	SNTOUT	MTHIN	CAUDPED	GIRTH	INBRB	OUTBRB
1	36.4	34.5	31.8	9.3	5.7	2.4	3.0	1.9	4.7	10.9	1.8	2.6
2	30.9	26.4	24.2	6.8	3.9	1.9	2.4	1.6	4.0	7.8	1.7	2.0
3	27.0	24.5	22.7	6.8	3.3	1.9	2.0	1.4	3.8	0.0	1.7	2.3
4	25.6	20.1	18.1	5.1	2.8	1.3	1.4	1.2	3.5	6.4	1.2	1.6
5	26.4	23.2	21.6	6.2	3.5	1.6	2.0	1.4	3.0	7.3	0.9	1.6
6	31.2	29.0	26.9	7.9	4.4	1.9	2.6	1.8	3.7	8.6	1.7	2.3
7	29.0	25.2	23.1	6.7	3.7	1.8	2.3	1.6	3.7	7.8	1.6	1.9
8	27.1	24.6	22.8	6.5	3.6	1.9	2.3	1.7	3.6	7.7	1.4	1.9
9	29.7	27.9	25.9	7.4	4.0	2.2	2.4	1.6	4.0	8.4	1.7	2.2
10	24.8	21.6	19.0	5.3	3.1	1.3	1.8	1.2	3.1	6.8	1.2	1.5
11	28.8	24.8	22.8	6.3	2.7	1.6	2.2	1.4	3.1	6.7	1.4	1.9
12	24.3	21.1	19.7	5.5	2.9	1.3	1.8	1.2	3.0	5.8	1.3	1.8
13	27.5	23.5	22.5	6.5	3.3	1.7	2.2	1.6	3.8	7.6	1.6	2.2
14	25.9	21.1	19.4	5.3	2.8	1.2	2.0	1.3	3.4	5.6	1.3	1.8
15	33.5	30.0	27.8	8.4	4.7	2.2	2.8	1.8	4.3	8.9	1.9	2.6
16	23.1	20.8	19.3	5.8	3.3	1.4	1.9	1.2	3.5	6.0	1.3	1.6
17	29.3	25.5	23.6	7.1	3.9	1.9	2.2	1.6	4.2	7.3	1.5	2.0
18	25.4	22.6	20.9	6.1	2.8	1.3	1.8	1.3	3.7	6.6	1.3	1.9
19	18.5	16.7	15.6	4.2	2.3	1.2	1.4	1.0	2.8	5.2	1.0	1.3
20	19.2	13.4	12.1	3.7	2.1	1.0	1.2	0.7	2.6	4.1	0.6	1.0
21	26.2	23.5	21.7	6.5	3.8	1.7	2.3	1.3	3.6	6.7	1.3	1.9
22	26.5	24.0	22.2	6.5	3.6	1.6	2.3	1.4	3.7	7.1	1.6	1.8
23	24.9	22.8	21.0	5.7	2.9	1.4	1.9	1.4	3.5	6.8	1.2	1.7
24	25.7	21.7	20.1	5.5	2.9	1.6	1.8	1.3	3.5	6.4	1.3	1.7
25	35.0	33.1	30.5	9.2	5.3	2.4	3.4	1.9	4.2	1.1	1.9	2.5
26	32.6	30.5	28.8	8.0	3.9	2.0	2.4	1.8	4.2	10.2	1.8	2.5
27	25.5	22.5	21.4	6.0	3.1	1.7	1.9	1.4	3.5	6.6	1.3	1.7
28	27.2	24.9	23.1	6.6	3.3	1.8	2.0	1.6	4.0	7.3	1.4	2.0
29	26.1	24.8	23.1	6.9	3.6	1.6	2.3	1.6	3.5	7.0	1.5	1.7
30	27.0	24.9	22.9	6.2	3.1	1.6	1.8	1.4	3.8	7.0	1.3	1.9
31	28.9	25.8	24.1	6.7	3.7	1.9	2.3	1.6	3.6	9.5	1.3	1.8
32	25.6	24.6	22.9	6.5	3.7	1.8	2.2	1.4	3.7	7.1	1.4	2.2
33	25.1	23.6	21.9	6.4	3.8	1.6	2.4	1.4	3.6	7.0	1.3	1.7
34	26.0	24.4	22.5	6.1	3.4	1.7	1.9	1.4	3.8	7.2	1.4	1.9

Missouri River
percent of standard length

row	HLP	SNTLE	MWP	SNTOU	MTHIN	INBRE	CAUDP	GIRTH	OUTBR
1	29.2	17.9	7.5	9.4	6.0	5.7	14.8	34.3	8.2
2	28.1	16.1	7.9	9.9	6.6	6.8	16.5	32.2	8.1
3	30.0	14.5	8.4	8.8	6.2	7.3	16.7	0.0	9.9
4	28.2	15.5	7.2	7.7	6.6	6.6	19.3	35.4	8.6
5	28.7	16.2	7.4	9.3	6.5	4.2	13.9	33.8	7.4
6	29.4	16.4	7.1	9.7	6.7	6.3	13.8	32.0	8.4
7	29.0	16.0	7.8	10.0	6.9	6.9	16.0	33.8	8.2
8	28.5	15.8	8.3	10.1	7.5	6.1	15.8	33.8	8.1
9	28.6	15.4	8.5	9.3	6.2	6.6	15.4	32.4	8.3
10	27.9	16.3	6.8	9.5	6.3	6.3	16.3	35.8	7.9
11	27.6	11.8	7.0	9.6	6.1	6.1	13.6	29.4	8.3
12	27.9	14.7	6.6	9.1	6.1	6.6	15.2	29.4	9.1
13	28.9	14.7	7.6	9.8	7.1	7.1	16.9	33.8	9.8
14	27.3	14.4	6.2	10.3	6.7	6.7	17.5	28.9	9.3
15	30.2	16.9	7.9	10.1	6.5	6.8	15.5	32.0	9.2
16	30.1	17.1	7.3	9.8	6.2	6.5	18.1	31.1	8.3
17	30.1	16.5	8.1	9.3	6.8	6.4	17.8	30.9	8.3
18	29.2	13.4	6.2	8.6	6.2	6.0	17.7	31.6	8.9
19	26.9	14.7	7.7	9.0	6.4	6.4	17.9	33.3	8.0
20	30.6	17.4	8.3	9.9	5.8	5.0	21.5	33.9	8.3
21	30.0	17.5	7.8	10.6	6.0	5.8	16.6	30.9	8.8
22	29.3	16.2	7.2	10.4	6.3	7.2	16.7	32.0	8.1
23	27.1	13.8	6.7	9.0	6.7	5.7	16.7	32.4	8.1
24	27.4	14.4	8.0	9.0	6.5	6.5	17.4	31.8	8.5
25	30.2	17.4	7.9	11.1	6.2	6.1	13.8	3.6	8.0
26	27.8	13.5	6.9	8.3	6.3	6.1	14.6	35.4	8.7
27	28.0	14.5	7.9	8.9	6.5	5.8	16.4	30.8	7.7
28	28.6	14.3	7.8	8.7	6.9	6.1	17.3	31.6	8.7
29	29.9	15.6	6.9	10.0	6.9	6.5	15.2	30.3	7.4
30	27.1	13.5	7.0	7.9	6.1	5.7	16.6	30.6	8.1
31	27.8	15.4	7.9	9.5	6.6	5.4	14.9	39.4	7.5
32	28.4	16.2	7.9	9.6	6.1	6.1	16.2	31.0	9.6
33	29.2	17.4	7.3	11.0	6.4	5.7	16.4	32.0	7.5
34	27.1	15.1	7.6	8.4	6.2	6.0	16.9	32.0	8.2

Yellowstone River
empirical measurements

row	TLIN	FL	SL	HL	SNTL	MW	SNTO	MTHI	CAUD	GIR	INBR	OUTBR
1		25.3	24.0	7.3	3.8	1.4	2.2	1.6	4.1	9.0	1.2	1.7
2		34.2	31.7	9.2	4.9	2.2	3.0	2.0	4.810.2		1.7	2.4
3		30.6	28.2	8.8	4.7	2.2	2.6	2.0	3.710.8		1.9	2.6
4		26.0	24.4	6.1	3.8	1.8	2.4	1.6	3.8	8.0	1.6	2.1
5		30.6	28.7	8.9	4.7	2.4	2.8	1.9	3.8	9.8	1.9	2.3
6		21.6	20.2	5.6	3.0	1.2	1.9	1.3	3.5	6.6	1.2	1.7
7		26.8	24.6	7.3	4.0	1.7	2.3	1.6	4.0	7.9	1.4	2.0
8		19.0	17.4	5.0	3.0	1.2	1.8	1.3	3.2	5.6	1.1	1.4
9		30.5	28.3	8.3	4.3	2.0	2.5	1.6	3.7	9.2	2.0	2.2
10		25.2	23.9	7.2	3.8	1.9	2.2	1.6	3.2	7.9	1.4	1.9
11		29.8	28.2	8.0	4.7	2.2	3.0	1.6	4.3	9.4	1.7	2.2
12		31.1	29.3	9.4	5.3	2.3	3.2	1.8	3.710.0		1.6	2.2
13		28.4	26.5	7.6	4.6	2.3	1.9	1.6	3.8	8.5	1.4	2.0
14		29.0	27.8	7.7	4.2	1.9	2.9	1.7	4.010.2		1.8	2.4
15		30.7	29.4	8.5	4.7	2.3	3.0	1.8	3.8	9.7	2.0	2.8
16		31.6	28.9	8.4	4.7	1.6	2.9	1.9	4.8	9.6	2.0	2.8
17		24.2	22.3	6.4	3.5	1.6	2.2	1.6	4.0	7.1	1.6	2.0
18		16.3	15.2	3.8	2.2	1.1	1.4	0.8	3.0	4.8	1.0	1.1
19		33.0	31.3	9.1	5.0	2.3	2.8	1.7	4.411.0		2.0	2.5
20		29.2	27.0	8.3	4.8	2.3	2.8	1.7	3.6	9.5	1.8	2.4
21		29.6	27.6	8.2	4.9	2.0	2.9	1.6	4.2	9.2	1.6	2.3
22		30.0	28.2	8.2	4.6	2.2	2.8	1.7	4.4	9.6	1.7	2.5
23		30.4	28.3	8.3	4.7	2.3	2.8	1.8	4.410.0		1.7	2.4
24		31.3	29.3	8.2	4.2	2.3	2.4	1.8	4.210.0		1.9	2.5
25		20.9	19.1	5.6	3.2	2.2	1.3	1.2	3.2	6.6	1.2	1.8
26		31.0	28.8	8.0	4.3	1.9	2.4	2.0	4.210.1		1.9	2.5
27		30.5	28.3	8.4	4.7	1.9	3.0	1.9	4.0	9.0	1.9	2.5
28		31.6	29.8	8.8	4.7	2.4	2.5	1.9	4.310.4		1.9	2.3
29		30.6	28.8	8.2	4.8	2.2	2.8	1.7	3.810.3		1.8	2.5
30		30.8	29.0	8.3	4.6	2.3	2.5	1.7	3.8	9.7	1.9	2.4
31		30.1	28.2	8.4	4.7	2.3	2.6	1.8	4.410.0		1.9	2.2
32		33.4	31.2	9.5	5.2	2.5	3.0	1.9	4.1	9.7	2.0	2.6
33		29.6	27.6	8.2	4.7	2.0	2.8	1.9	3.8	9.0	1.3	2.3
34		28.4	26.2	8.0	4.6	1.9	2.9	1.8	3.8	9.1	1.9	2.6
35		34.6	32.3	9.4	4.8	2.5	3.1	2.2	4.412.0		2.3	3.1
36		29.6	27.5	7.8	4.6	2.3	2.9	1.6	4.2	8.9	1.5	2.2
37		27.8	25.5	7.6	3.9	2.0	2.6	1.8	3.0	9.8	1.8	2.8
38		32.2	30.1	8.6	4.0	2.4	2.5	1.8	4.6	8.8	1.9	2.8
39		27.3	25.1	7.5	3.8	1.8	2.4	1.4	4.0	8.0	1.6	2.3
40		24.5	22.6	6.5	3.2	1.7	2.3	1.6	3.6	7.7	1.4	2.0

Yellowstone River
percent of standard length

row	HLP	SNTLE	MWP	SNTOU	MTHI	OUTB	CAUDP	GIRT	INBE
1	30.5	16.0	6.0	9.0	6.5	7.0	17.0	37.5	5.0
2	29.2	15.5	6.8	9.5	6.4	7.6	15.2	32.2	5.5
3	31.1	16.6	7.7	9.4	7.2	9.1	13.2	38.3	6.8
4	25.1	15.8	7.4	9.9	6.4	8.6	15.8	33.0	6.4
5	31.0	16.3	8.4	9.6	6.7	7.9	13.4	34.3	6.7
6	28.0	14.9	6.0	9.5	6.5	8.3	17.3	32.7	6.0
7	29.8	16.1	6.8	9.3	6.3	8.3	16.1	32.2	5.9
8	29.0	17.2	6.9	10.3	7.6	8.3	18.6	32.4	6.2
9	29.2	15.3	7.2	8.9	5.5	7.8	13.1	32.6	7.0
10	30.2	16.1	8.0	9.0	6.5	8.0	13.6	33.2	6.0
11	28.5	16.6	7.7	10.6	5.5	7.9	15.3	33.2	6.0
12	32.0	18.0	7.8	11.1	6.1	7.6	12.7	34.0	5.5
13	28.5	17.2	8.6	7.2	5.9	7.5	14.5	32.1	5.4
14	27.6	15.1	6.9	10.3	6.0	8.6	14.2	36.6	6.5
15	29.0	15.9	7.8	10.2	6.1	9.4	13.1	33.1	6.9
16	29.0	16.2	5.4	10.0	6.6	9.5	16.6	33.2	7.1
17	28.5	15.6	7.0	9.7	7.0	9.1	17.7	31.7	7.3
18	25.2	14.2	7.1	9.4	5.5	7.5	19.7	31.5	6.3
19	29.1	16.1	7.3	8.8	5.4	8.0	14.2	35.2	6.3
20	30.7	17.8	8.4	10.2	6.2	8.9	13.3	35.1	6.7
21	29.6	17.8	7.4	10.4	5.7	8.3	15.2	33.5	5.9
22	28.9	16.2	7.7	9.8	6.0	8.7	15.7	34.0	6.2
23	29.2	16.5	8.1	9.7	6.4	8.5	15.7	35.2	6.1
24	27.9	14.3	7.8	8.2	6.1	8.6	14.3	34.0	6.6
25	29.6	17.0	11.3	6.9	6.3	9.4	17.0	34.6	6.3
26	27.9	15.0	6.7	8.3	7.1	8.8	14.6	35.0	6.7
27	29.7	16.5	6.8	10.6	6.8	8.9	14.0	31.8	6.8
28	29.4	15.7	8.1	8.5	6.5	7.7	14.5	35.1	6.3
29	28.3	16.7	7.5	9.6	5.8	8.8	13.3	35.8	6.3
30	28.5	15.7	7.9	8.7	5.8	8.3	13.2	33.5	6.6
31	29.8	16.6	8.1	9.4	6.4	7.7	15.7	35.3	6.6
32	30.4	16.5	8.1	9.6	6.2	8.5	13.1	31.2	6.5
33	29.6	17.0	7.4	10.0	7.0	8.3	13.9	32.6	4.8
34	30.7	17.4	7.3	11.0	6.9	10.1	14.7	34.9	7.3
35	29.0	14.9	7.8	9.7	6.7	9.7	13.8	37.2	7.1
36	28.4	16.6	8.3	10.5	5.7	7.9	15.3	32.3	5.5
37	29.8	15.3	8.0	10.4	7.1	11.1	11.8	38.6	7.1
38	28.6	13.3	8.0	8.4	6.0	9.2	15.1	29.1	6.4
39	29.9	15.1	7.2	9.6	5.7	9.1	15.8	32.0	6.2
40	28.8	14.2	7.4	10.1	6.9	8.8	15.9	34.0	6.4